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**(54) Device for measuring information on blood in a living object**

Gerät zur Messung von Blutinformation bei einem Lebewesen

Appareil de mesure d'information sanguine d'un objet vivant

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**EP-A- 0 502 270**                      **EP-A- 0 615 723**

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pulse oximetry at various haematocrits and  
during haemolysis in an in vitro model'

**EP 0 616 791 B1**

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## Description

- [0001] The present invention relates to a measuring device that measures at least blood flow, oxygen saturation level in the blood, or the absolute concentration of hemoglobin of blood in a living object injected with a liquid (for example, a physiological salt solution) that is safe for living objects.
- [0002] Supply of blood to various organs of living objects is an essential factor for maintaining the life of living objects and for living objects to function properly. Blood supply to the brain is particularly important. Measuring cerebral blood flow is an indispensable tool for patients where there is a danger of the brain falling into a critical condition. In one conventional technique, a radioactive substance, such as radioactive xenon, is injected into a living object as a tracer. Changes in the tracer are measured by a  $\gamma$ -ray sensor attached to the head of a subject under investigation. Blood flow is then calculated. In another technique, the tracer injected is a pigment, such as cardio-green. By monitoring the flow of the pigment according to changes in the amount of light irradiated from an external source that is absorbed by the pigment, the blood flow is then calculated.
- [0003] U.S. Patent No. 4281645 describes a device for measuring changes in blood oxygen and blood concentration in the brain (not cerebral blood flow itself). This device uses near-infrared (NIR) light as a light source. Living tissue is comparatively transparent to NIR light. The device also uses an extremely sensitive sensor, such as a photomultiplier tube, in the optical detector. Although previously only measurements of thin body portions such as finger tips and ear lobes was possible, this device allows measurements of the head. This reference describes clinical monitoring of the head which allows measurements of changes in concentration of oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin (Hb) in the blood in the head.
- [0004] There have been known the following problems with the above-described device. Measurements can not be repeatedly performed, because tracers such as pigments and radioactive materials are undesirable to living objects. Also, countries and organizations often prohibit injecting these tracers into human subjects. Although more stable and more precise than another conventional technique using the Doppler effect which measures blood flow from the wavelength shift of an ultrasonic wave, measurement of blood flow using such tracers is difficult in a clinical situation. Although a device (hereinafter referred to as an NIR monitor) which measures changes in blood concentration and blood oxygen in the head using NIR light can measure the relative change in oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin (Hb), it can not obtain the absolute value, and so direct information relating to the important cerebral blood flow can not be obtained.
- [0005] EP-A-0 502 270 discloses a device for measuring information on blood according to the first part of claim 1. The present invention is characterised by the technical features stated in the characterising portion of claim 1.
- [0006] Our earlier EP-A-0615723 which was published after the earliest priority date of this case but which has an earlier priority date discloses a blood measuring device including irradiation means for irradiating light on a predetermined position of a part of a living object; detection means for detecting light derived from the living object; and converting means for converting the detected light into a first electric signal, and calculation means for performing a first calculation process on the first electric signal to output a second electric signal representing a change in concentration of hemoglobin at the predetermined position of the part of the living object wherein the change in concentration of hemoglobin is caused by injecting a blood diluting liquid into the living object, and for performing a second calculation process on the second electric signal to calculate a blood flow, an absolute concentration of hemoglobin and optionally a degree of oxidation of hemoglobin.
- [0007] The device according to the present invention is differentiated vis à vis the device according to EP-A-0 615 723 in that said calculation means calculates the blood flow in the predetermined position of the part of the living object based on the absolute concentration of hemoglobin calculated by said calculation means.
- [0008] Preferably the calculation means calculates a passage time required for the blood diluting liquid injected into the living object to pass the predetermined position of the part of the living object, and the blood flow is obtained based on the calculated passage time.
- [0009] Preferably, the calculating means outputs a third signal representing changes in concentration of oxyhemoglobin and a fourth signal representing changes in concentration of deoxyhemoglobin. The calculating means calculates at least one of the blood flow, the degree of oxidation of hemoglobin and the absolute concentration of hemoglobin based on at least one of the third signal and the fourth signal.
- [0010] The irradiation means alternately irradiates the predetermined position of the part of the living object with light having at least two types of wavelength to obtain the third signal and the fourth signal. The light irradiated by the irradiation means to obtain the third signal and the fourth signal has wavelengths of 775nm and 825nm, respectively. The physiological salt solution used as the blood diluting liquid has a light absorption coefficient which is negligible compared to the light absorption coefficients of oxyhemoglobin and deoxyhemoglobin.
- [0011] A particular embodiment of a device in accordance with the invention will now be described in connection with the accompanying drawings, in which:-

Fig. 1 is a schematic block diagram showing a device according to an embodiment of the present invention;

Fig. 2(a) is a graphical representation showing change in concentration of oxyhemoglobin; Fig. 2(b) is a graphical representation showing change in concentration of deoxyhemoglobin; Fig. 2(c) is a graphical representation showing change in concentration in the total volume of hemoglobin;

Fig. 3 is a graphical representation showing changes in concentration of hemoglobin measured over several times.

Figs. 4(a) and 4(b) are graphical representations showing changes in concentration in volume of total hemoglobin and changes in concentration in oxyhemoglobin, respectively, for describing a method of determining passage time of physiological salt solution injected into the blood stream; and

Fig. 5 is a flow chart showing procedure for determining passage time.

[0012] Fig. 1 shows a schematic structural diagram of the device according to an embodiment of the present invention. In Fig. 1, a light source 3 is connected to a central processing unit (hereinafter referred to as a CPU) 1 via a laser driver 2. Two types of different wavelength light are outputted by the light source 3: laser light 1 with wavelength  $\lambda_1$  and laser light 2 with wavelength  $\lambda_2$ . Laser light wavelength  $\lambda_1$  is 775 nm and laser light wavelength  $\lambda_2$  is 825 nm. These laser light wavelengths are alternately outputted based on the control of the CPU 1. The laser light 1 with wavelength  $\lambda_1$  and laser light 2 with wavelength  $\lambda_2$  are for measuring the concentration of oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin (Hb).

[0013] An irradiation-side fastener 5A is attached to the head 4 of the test subject for irradiating the head 4 of the test subject with laser light outputted by the light source 3. The irradiation-side fastener 5A supports the tip of a bundle of optical fibers for guiding the laser light. A detection-side fastener 5B is fastened at a predetermined interval (5 to 6 cm) from the irradiation-side fastener 5A. The distance between the irradiation-side fastener 5A and the detection-side fastener 5B is the length of the optical pathway. The laser light detected by the detection-side fastener 5B is guided toward a photomultiplier tube 6 by optical fibers. After the output from the photomultiplier tube 6 is subjected to analog-to-digital conversion at an analog/digital converter 7, it is stored in a memory 8 at a predetermined timing. A signal is stored in the memory 8 every 0.5 seconds. The CPU 1 outputs changes in concentration of oxyhemoglobin  $\Delta\text{HbO}_2$ , the change in concentration of deoxyhemoglobin  $\Delta\text{Hb}$ , and the change in concentration of total hemoglobin  $\Delta\text{HbT}$  ( $\text{HbT} = \text{HbO}_2 + \text{Hb}$ ) to an output device 9 every 0.5 seconds. Parameters necessary for the CPU 1 to perform various calculations and programs for driving the CPU 1 are stored in the memory 8. The start switch 10 is for advising the CPU 1 that a measurement of blood flow has started.

[0014] The present embodiment measures the absolute value of the level of oxygen saturation cerebral blood flow ( $\text{SO}_2$ ) and the cerebral blood flow (F) using physiological salt solution as a tracer simultaneously with the absolute concentration of the oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin (Hb). The physiological salt solution used as a tracer is itself a body fluid and so is harmless to the human body. Liquids other than physiological salt solution can be used for diluting the blood if they have an absorption coefficient negligible compared to that of hemoglobin in the wavelength range of the utilized laser light and moreover if the safety to living objects is assured.

#### (1) Measurement of blood flow

[0015] The cerebral blood flow F is the amount of blood flowing to the brain during a unit of time. Blood flow can be determined using the following formula:

$$F = V/T,$$

where

V is the volume of blood in the brain; and

T is the time required for V amount of blood to pass through the brain. The volume of blood in the brain can be measured using, for example, a near infrared (NIR) monitor. Therefore, the cerebral flow F can be determined by determining passage time T. When measuring with an NIR monitor, the volume of blood in the brain will be displayed in units of either ml/100 g of brain or concentration of hemoglobin in  $\mu$  moles/liter. If the passage time T is displayed in seconds, the cerebral blood flow will be displayed in ml/100 g of brain/second or  $\mu$  moles/liter/second.

[0016] Below the measurement method of the passage time T will be described.

[0017] Injecting physiological salt solution into an artery slightly dilutes the portion of the blood into which the solution was injected. This condition is virtually maintained until the blood reaches the brain. Afterward, the blood passes through capillary vessels and leaves the head after entering the veins therein. An NIR monitor is mounted to the head and the change in hemoglobin ( $\text{HbO}_2$  and Hb) in the brain is monitored. When several centiliters of physiological salt solution is injected over a short period of time,  $\mu$  moles/liter order changes in concentration of hemoglobin (the hemo-

globin dilution) in the head are observed over a period of several seconds to several tens of seconds. Fig. 2 is a graph showing the change in concentration of hemoglobin. Fig. 2(a) shows the change in concentration of oxyhemoglobin,  $\Delta\text{HbO}_2$ , Fig. 2(b) shows the change in concentration of deoxyhemoglobin,  $\Delta\text{Hb}$ , and Fig. 2(c) shows the change in concentration in the total volume of hemoglobin,  $\Delta(\text{HbO}_2 + \text{Hb})$ .

5 [0018] The passage time  $T$  required for physiological salt solution injected into an artery to pass a measurement position in a part of the brain has applied to it a value determined by dividing the integral value  $S$  of the change in concentration of the blood by the maximum volume  $h$  of change in concentration ( $T = S/h$ ). When physiological salt solution is injected into the blood, the blood is diluted and the concentration of the hemoglobin ( $\text{HbO}_2 + \text{Hb}$ ) drops. The change in concentration of the hemoglobin is measured at a predetermined interval to determine the total measured value ( $S$ ) and the maximum amount of the change in concentration ( $h$ ), thus obtaining the passage time  $T$ .

10 [0019] The oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin ( $\text{Hb}$ ) are diluted with the injected physiological salt solution at the same rate and so the form of their concentration changes is the same. Therefore, no matter which of the curves in Figs. 2(a) through 2(c) are used, the value obtained by dividing the area of the change portion by the maximum change amount provides the same result (i.e.,  $T = S_x/h_x = S_y/h_y = (S_x + S_y)/(h_x + h_y)$ ).

15 [0020] The passage time  $T$  can also be determined based on the graph created by taking the relative value of the measured concentration of the hemoglobin along the vertical axis. That is, the passage time  $T$  can be determined by applying only the shape of the change in concentration of the oxyhemoglobin ( $\text{HbO}_2$ ) or the deoxyhemoglobin ( $\text{Hb}$ ).

[0021] A concrete method for determining the passage time  $T$  will be described while referring to Figs. 4 and 5. In the present embodiment, the changes in volume of both oxyhemoglobin ( $\text{HbO}_2$ ) and deoxyhemoglobin ( $\text{Hb}$ ) are determined. Passage time  $T$  is determined based on the change in volume of the total hemoglobin ( $\text{HbT} = \text{HbO}_2 + \text{Hb}$ ). This is because the change in volume of total hemoglobin is greater than either the change in volume of oxyhemoglobin ( $\text{HbO}_2$ ) or deoxyhemoglobin ( $\text{Hb}$ ).

[0022] An operator presses the switch 10 and injects a predetermined amount of physiological salt solution into the living object. The CPU 1 receives the signal outputted from the start switch 10 and performs initialization of the parameters  $k$  and  $h$  in step S1. Afterward, the time point  $T_k$  when the change in concentration in the total volume of hemoglobin  $\Delta\text{HbT}$  starts to decrease because of the injected physiological salt solution is detected. The detection of the time point  $T_k$  is accomplished by finding a time point when the concentration drops "a"  $\mu$  moles or more from the value of  $\Delta\text{HbT}(T_0)$  representing the level of  $\Delta\text{HbT}$  when the start switch 10 is pushed, as shown in Fig. 4(a) (steps S2 and S3). The value of "a" is selected depending on the amount of noise contained in the signal to be measured. Generally, it is desirable that 1/10 of the maximum reduction level of the  $\Delta\text{HbT}$  curve be determined as the value of "a". When  $T_k$  is detected, the average amount of the  $\Delta\text{HbT}$  from  $T_0$  to  $T_k-1$  is calculated to determine a reference level  $[\text{HbT}]_{\text{ave}}$ . After  $T_k$ , while the physiological salt solution is passing, the  $\Delta\text{HbT}$  will show a value smaller than  $[\text{HbT}]_{\text{ave}}$ . The point in time  $T_k+h$  when this again increases larger than the  $[\text{HbT}]_{\text{ave}}$  is detected in step S5. Further, the minimum value  $\text{HbT}_{\text{min}}$  of the  $\Delta\text{HbT}$  is detected in step S7. At this point, data collection is stopped and later calculation of necessary values are performed.

35 [0023] First, the total of the change in concentration of  $\text{HbO}_2$  and  $\text{HbT}$  during the time from  $T_k$  to  $T_k+h$  are determined in step S8. That is, the areas  $\text{SHbT}$  and  $\text{SHbO}_2$  of the hashed areas shown in Figs. 4(a) and 4(b) are determined, the degree of oxygen saturation  $\text{SO}_2$  is calculated, and the result is displayed on the output device 8 in step S9. The oxygen saturation level  $\text{SO}_2$  is applied to the ratio between the total amount of change in concentration of  $\text{HbO}_2$  and  $\text{HbT}$ . Next, the passage time  $T$  is calculated. The result is displayed by the output device 9 in step S10. The passage time  $T$  is calculated based on the maximum value of the change in concentration of  $\text{HbT}$  and the total  $\text{SHbT}$  of the change in concentration of  $\text{HbT}$ . Because the maximum value of the change in concentration of  $\text{HbT}$  is the difference between the reference level  $[\text{HbT}]_{\text{ave}}$  of  $\text{HbT}$  determined in step S4 and the minimum value  $\text{HbT}_{\text{min}}$  of  $\text{HbT}$  detected in step S7, the passage time  $T$  can be determined with the following formula:

$$T = \text{SHbT} / ([\text{HbT}]_{\text{ave}} - \text{HbT}_{\text{min}}).$$

[0024] This finishes the algorithm for determining the passage time.

50 [0025] The cerebral blood flow ( $F$ ) is determined with calculations using the formula  $F = V/T$  based on the passage time  $T$  obtained from the above calculations and the volume  $V$  ( $\text{cc}/\text{cm}^3$  or  $\mu$  moles) of cerebral blood as measured separately. This calculation is also performed using the CPU 1. The results are displayed on the output device 9. The method of measuring the cerebral blood volume ( $V$ ) is described in the 1990 edition of "The Journal for the American Physiological Science Conference", pp 1086 to 1091.

55 (2) Measurement of absolute value of oxygen saturation ( $\text{SO}_2$ ) in cerebral blood flow

[0026] The absolute value of oxygen saturation ( $\text{SO}_2$ ) in cerebral blood flow is determined by calculating the ratio between  $\text{SHbT}$  in regards to  $\text{SHbO}_2$  as determined in step S9 in Fig. 5. This is equivalent to the ratio of the amount of

change corresponding to the oxyhemoglobin and the total hemoglobin. For example, by the maximum value of the change in concentration of deoxyhemoglobin  $h_y$  and oxyhemoglobin  $h_x$  and, the level of oxygen saturation in cerebral blood is determined by the formula:

$$So_2 = h_x / (h_x + h_y).$$

[0027] As described above, along with the injection of physiological salt solution, oxyhemoglobin ( $HbO_2$ ) and deoxyhemoglobin ( $Hb$ ) are diluted in the same way. Therefore the changes in their volumes is proportional to the concentration itself. In Figs. 2(a) through 2(c), if the ratio of  $h_x$  to  $h_y$  is three to one, then the ratio of the concentration of  $HbO_2$  to  $Hb$  is also three to one and the absolute value of the level of oxygen saturation in hemoglobin is 75%. Components necessary for this calculation are the change in total amount ( $S_x$ ,  $S_y$ ) of change in concentration of oxyhemoglobin ( $HbO_2$ ) and deoxyhemoglobin ( $Hb$ ) or the maximum value ( $h_x$  and  $h_y$ ) of the change in concentration. Therefore, all that needs to be known is the shape of the change. The vertical axis in Figs. 2(a) through 2(c) can be the relative value of the change in concentration. This means that after quantitating the change in concentration, measurement can be made without relation to the weak point of NIR monitors, i.e., the need for assuming the average distance travelled by the light (the optical pathway).

### (3) Measurement of the absolute concentration of $HbO_2$ and $Hb$

[0028] By measuring the change in concentration of oxyhemoglobin ( $HbO_2$ ) and deoxyhemoglobin ( $Hb$ ) at least two points in time wherein the concentration of hemoglobin differs, the absolute concentration of these can be determined.

[0029] As shown in Fig. 3, the change in concentration of oxyhemoglobin  $h_{x1}$  and the change in concentration of deoxyhemoglobin  $h_{y1}$  are measured in the first measurement of blood flow performed at time period A. The change in concentration of oxyhemoglobin  $h_{x2}$  and the change in concentration of deoxyhemoglobin  $h_{y2}$  are measured in the same way also at the second measurement of blood flow performed during time period B. Further, the differences between the average concentrations measured in the first and second blood flow measurements for both oxyhemoglobin and deoxyhemoglobin are determined. Assuming that the absolute concentration of oxyhemoglobin and deoxyhemoglobin during time period (A) are  $AHbO_2$  and  $AHb$  respectively, the following equation can be formed:

$$AHbO_2 : AHb = h_{x1} : h_{y1}$$

$$(AHbO_2 + \Delta HbO_2) : (AHb + \Delta Hb) = h_{x2} : h_{y2}$$

[0030] From the above equations, the following can be determined:

$$AHbO_2 = \{h_{x1} / (h_{y2} \times h_{x1} - h_{y1} \times h_{x2})\} \times (\Delta Hb \times h_{x2} - \Delta HbO_2 \times h_{y2})$$

$$AHb = \{h_{y1} / (h_{y2} \times h_{x1} - h_{y1} \times h_{x2})\} \times (\Delta Hb \times h_{x2} - \Delta HbO_2 \times h_{y2})$$

[0031] By setting the sum of  $AHbO_2$  and  $AHb$  determined by the above method as the new cerebral blood volume  $V$ , this can be used in new blood flow calculations. At this time, when the second blood flow measurement is performed, after the first measurement (processing and calculation in Fig. 5) is finished, the CPU 1 monitors how much the present data  $\Delta HbO_2(t)$ ,  $\Delta Hb(t)$  has changed from the values for  $[HbO_2]_{ave/1}$ ,  $[Hb]_{ave/1}$  measured in the first measurement. When it exceeds a predetermined amount  $M$ , display is performed and that a second measurement is possible is advised. The predetermined amount  $M$  is normally set to about 5  $\mu$  moles, although this will vary with the amount of noise included in the measured value. After viewing this display, the operator will perform the second measurement (process and calculation in Fig. 5). The results of the second measurement are calculated by the CPU 1. The calculation portion determines the cerebral blood volume  $V$ , that is, the absolute concentration  $AHbT$  ( $\mu$  moles) of total hemoglobin from the results of the first and second measurements. Cerebral blood flow is newly calculated based on the thus-determined cerebral blood volume  $V$ .

[0032] The above-described embodiment described determining cerebral blood flow. However, the present invention is not limited to this. Blood flow in organs other than the brain can be determined using the same method.

[0033] As described above, according to the present invention, a body fluid (for example, physiological salt solution) with absolutely no harmful effects on living tissue is used to dilute the blood as a tracer. Therefore, measurement of blood flow can be performed safely and repeatedly. Measurement of the absolute value of oxygen saturation in blood and measurement of the absolute concentration of hemoglobin, both of which have been impossible using conventional NIR monitor devices, is possible. Because measurement of blood flow is possible based on the blood volume displayed by the hemoglobin concentration, this becomes a great resource to clinical diagnosis, especially of the brain.

[0034] The laser light wavelength  $\lambda_1$  may not be precisely 775nm but be a wavelength in the vicinity thereof. Likewise, the laser light wavelength  $\lambda_2$  may not be precisely 825nm but be a wavelength in the vicinity of 825nm.

#### Claims

- 5 1. A blood measuring device including irradiation means (3) for irradiating light on a predetermined position of a part of a living object (4); detection means (6) for detecting light derived from the living object (4); and converting means (6) for converting the detected light into a first electric signal, and calculation means (1) characterized in that said calculation means performs a first calculation process on the first electric signal to output a second electric signal representing a change in concentration of hemoglobin at the predetermined position of the part of the living object wherein the change in concentration of hemoglobin is caused by injecting a blood diluting liquid into the living object, and performs a second calculation process on the second electric signal to calculate a blood flow, an absolute concentration of hemoglobin and optionally a degree of oxidation of hemoglobin; and said calculation means (1) calculates the blood flow in the predetermined position of the part of the living object (4) based on the absolute concentration of hemoglobin calculated by said calculation means.
- 10 2. A device according to claim 1, characterized in that said calculation means (1) calculates a passage time required for the blood diluting liquid injected into the living object to pass the predetermined position of the part of the living object, and calculates the blood flow based on the calculated passage time.
- 15 3. A device according to claim 1 or 2, characterized in that said calculating means outputs a third signal representing changes in concentration of oxyhemoglobin and a fourth signal representing changes in concentration of deoxyhemoglobin, and that said calculating means (1) calculates at least one of the blood flow, the degree of oxidation of hemoglobin and the absolute concentration of hemoglobin based on at least one of the third signal and the fourth signal.
- 20 4. A device according to any one of the preceding claims, characterized in that said irradiation means (3) alternately irradiates the predetermined position of the part of the living object with light having at least two types of wavelength to obtain the third signal and the fourth signal.
- 25 5. A device according to claim 4, characterized in that the light irradiated by said irradiation means (3) to obtain the third signal and the fourth signal has wavelengths of 775nm and 825nm, respectively.
- 30 6. A device according to claim 5, characterized in that the blood diluting liquid has a light absorption coefficient which is negligible compared with light absorption coefficients of oxyhemoglobin and deoxyhemoglobin.
- 35 7. A device according to claim 6, characterized in that the blood diluting liquid is physiological salt solution.

#### Patentansprüche

- 40 1. Blutmeßvorrichtung mit Bestahlungsmitteln (3), um eine vorher festgelegte Stelle eines Teiles eines lebenden Objektes (4) mit Licht zu bestrahlen; Empfänger (6) zum Empfang von Licht, welches von dem lebenden Objekt (4) zu dem Empfänger (6) geleitet wird; Umwandlungsmittel (7) zur Umwandlung des empfangenen Lichtes in ein erstes elektrisches Signal; sowie Berechnungsmittel (1),  
 45 dadurch gekennzeichnet, daß die Berechnungsmittel einen ersten Berechnungsvorgang bei dem ersten elektrischen Signal vornehmen, um ein zweites elektrisches Signal auszugeben, welches eine Veränderung der Hämoglobinkonzentration an der vorher festgelegten Stelle des Teiles des lebenden Objektes, an welcher die Veränderung der Hämoglobinkonzentration durch Injizieren einer blutverdünnenden Flüssigkeit in das lebende Objekt bewirkt wird, darstellt, und einen zweiten Berechnungsvorgang bei dem zweiten elektrischen Signal durchführen, um einen Blutstrom, eine absolute Hämoglobinkonzentration und wahlweise einen Oxidationsgrad von Hämoglobin zu berechnen, und daß die Berechnungsmittel (1) den Blutstrom an der vorher festgelegten Stelle des Teiles des lebenden Objektes (4) berechnen, welcher auf der absoluten Hämoglobinkonzentration, die mit Hilfe der Berechnungsmittel berechnet wurde, basiert;
- 50 2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Berechnungsmittel (1) eine Durchlaufzeit berechnen, welche die in das lebende Objekt injizierte, blutverdünnende Flüssigkeit benötigt, um die vorher festgelegte Stelle des Teiles des lebenden Objektes zu passieren; und daß diese den auf der berechneten Durchlaufzeit basierenden Blutstrom berechnen.
- 55

3. Vorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Berechnungsmittel ein drittes Signal ausgeben, welches Veränderungen der Oxyhämoglobinkonzentration darstellt, sowie ein viertes Signal ausgeben, welches Veränderungen der Desoxyhämoglobinkonzentration darstellt, und daß, basierend auf dem dritten bzw. vierten Signal, die Berechnungsmittel (1) den Blutstrom, den Oxidationsgrad von Hämoglobin bzw. die absolute Hämoglobinkonzentration berechnen.
4. Vorrichtung nach einem der vorangegangenen Ansprüche, dadurch gekennzeichnet, daß die Bestrahlungsmittel (3) die zuvor festgelegte Stelle des Teiles des lebenden Objektes wechselweise mit Licht bestrahlen, welches zumindest zwei Wellenlängentypen aufweist, um das dritte und das vierte Signal zu empfangen.
5. Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß das von den Bestrahlungsmitteln (3) ausgestrahlte Licht zum Empfang des dritten und vierten Signales eine Wellenlänge von 775nm bzw. 825nm aufweist.
6. Vorrichtung nach Anspruch 5, dadurch gekennzeichnet, daß die blutverdünnende Flüssigkeit einen Lichtabsorptionskoeffizienten aufweist, welcher, im Vergleich zu Lichtabsorptionskoeffizienten von Oxyhämoglobin und Desoxyhämoglobin, unbedeutend ist.
7. Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß die blutverdünnende Flüssigkeit durch eine physiologische Salzlösung dargestellt ist.

#### Revendications

1. Dispositif de mesure sanguine comportant un moyen d'irradiation (3) pour irradier de la lumière sur une position prédéterminée d'une partie d'un objet vivant (4), un moyen de détection (6) pour détecter de la lumière provenant de l'objet vivant (4) et un moyen de conversion (6) pour convertir la lumière détectée en un premier signal électrique et un moyen de calcul (1) caractérisé en ce que ledit moyen de calcul exécute un premier processus de calcul sur le premier signal électrique pour sortir un deuxième signal électrique représentant une variation de concentration de l'hémoglobine à la position déterminée de la partie de l'objet vivant, la variation de concentration de l'hémoglobine étant provoquée par l'injection d'un liquide diluant le sang dans l'objet vivant, et exécute un deuxième processus de calcul sur le deuxième signal électrique pour calculer un débit sanguin, une concentration absolue de l'hémoglobine et en option un degré d'oxydation de l'hémoglobine; et ledit moyen de calcul (1) calcule le débit sanguin à la position prédéterminée de la partie de l'objet vivant (4) basée sur la concentration absolue de l'hémoglobine calculée par ledit moyen de calcul.
2. Dispositif selon la revendication 1, caractérisé en ce que ledit moyen de calcul (1) calcule le temps de passage nécessaire pour que le liquide diluant le sang injecté dans l'objet vivant passe par la position prédéterminée de la partie de l'objet vivant et calcule le débit sanguin en se basant sur le temps de passage calculé.
3. Dispositif selon la revendication 1 ou 2, caractérisé en ce que ledit moyen de calcul émet un troisième signal représentant des variations de concentration de l'oxyhémoglobine et un quatrième signal représentant des variations de concentration de la déoxyhémoglobine, et en ce que ledit moyen de calcul (1) calcule au moins l'un des éléments suivants : débit sanguin, degré d'oxydation de l'hémoglobine et concentration absolue de l'hémoglobine en se basant au moins sur l'un des troisième signal et quatrième signal.
4. Dispositif selon l'une des revendications précédentes, caractérisé en ce que ledit moyen d'irradiation (3) irradie alternativement la position prédéterminée de la partie de l'objet vivant avec de la lumière ayant au moins deux types de longueur d'onde pour obtenir le troisième signal et le quatrième signal.
5. Dispositif selon la revendication 4; caractérisé en ce que la lumière irradiée par ledit moyen d'irradiation (3) pour obtenir le troisième signal et le quatrième signal a des longueurs d'onde de 775 nm et 825 nm, respectivement.
6. Dispositif selon la revendication 5; caractérisé en ce que le liquide diluant le sang a un coefficient d'absorption de lumière négligeable en comparaison des coefficients d'absorption de lumière de l'oxyhémoglobine et de la déoxyhémoglobine.
7. Dispositif selon la revendication 6, caractérisé en ce que le liquide diluant le sang est une solution de sel physiologique.

FIG. 1

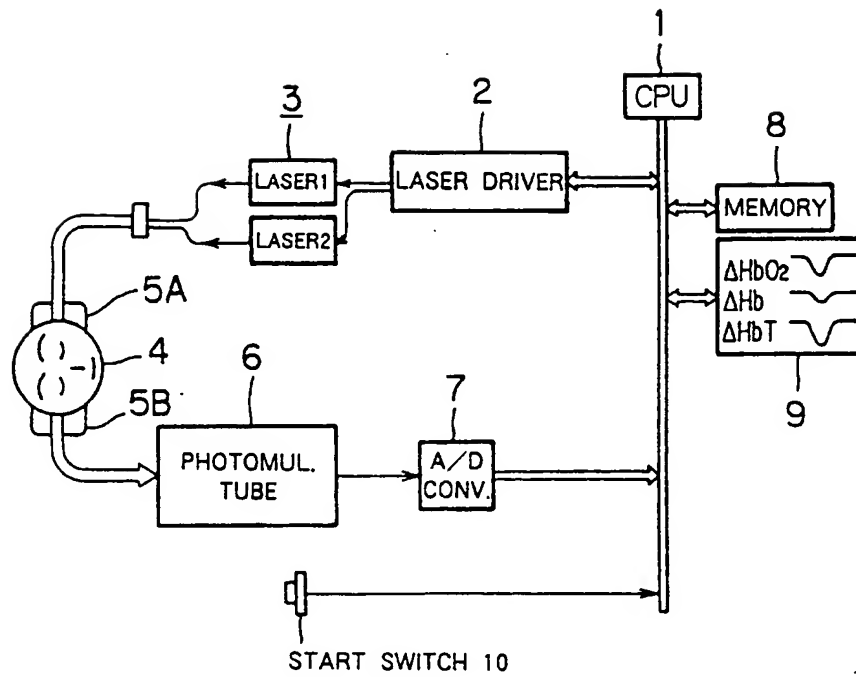
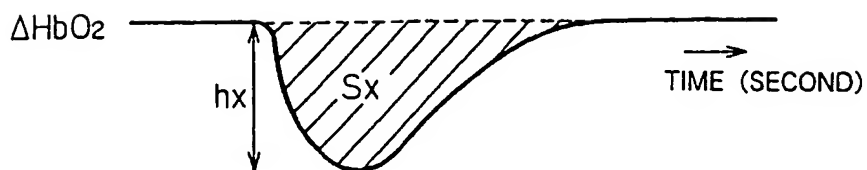


FIG. 2 (a)



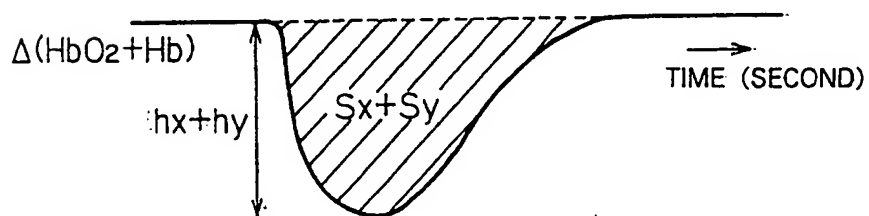
CHANGE IN CONCENTRATION OF HbO<sub>2</sub> ( $\Delta \text{HbO}_2$ )

FIG. 2 (b)



CHANGE IN CONCENTRATION OF Hb ( $\Delta \text{Hb}$ )

FIG. 2 (c)



CHANGE IN CONCENTRATION OF ( $\text{HbO}_2 + \text{Hb}$ )

FIG. 3

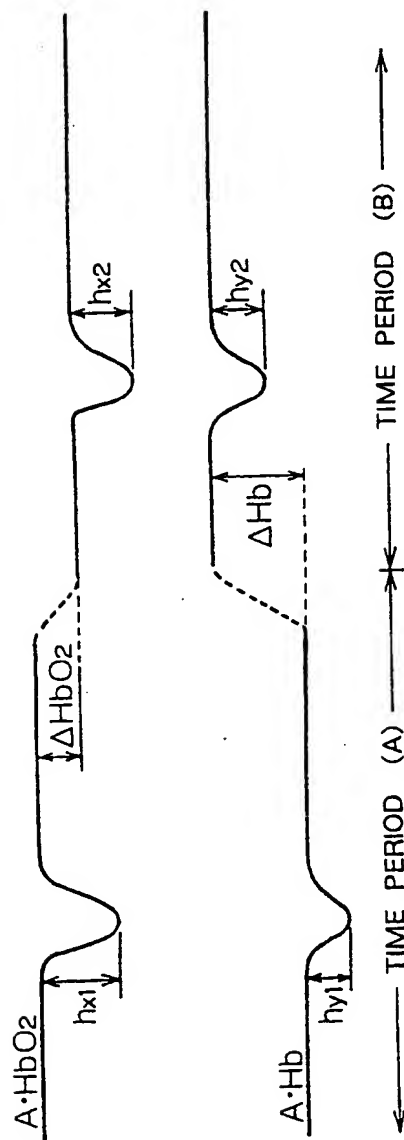


FIG. 4 (a)

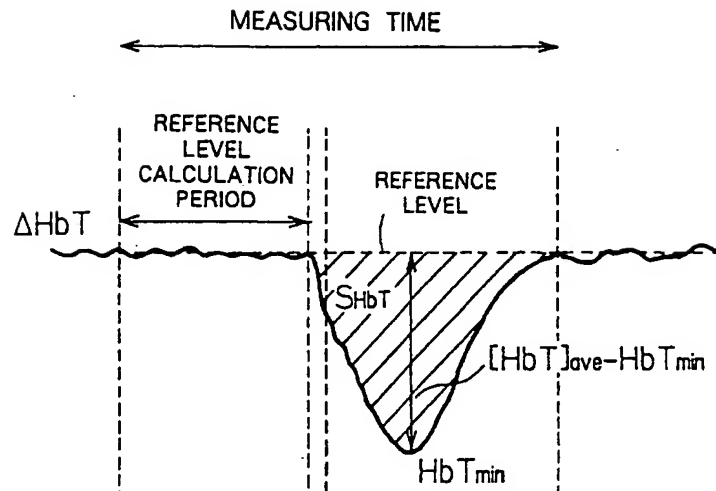


FIG. 4 (b)

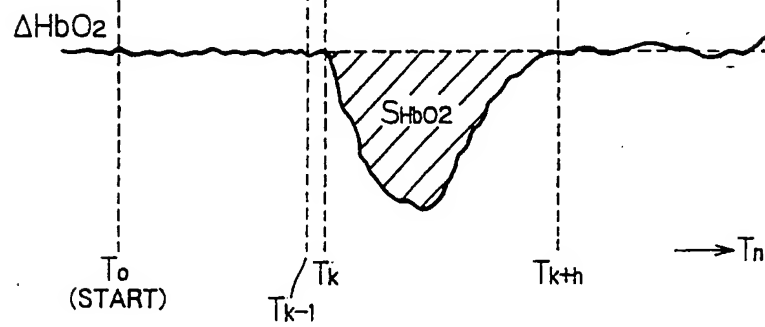


FIG. 5

